Appendix D

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Meteorological data for more than 200 meteorological stations in the United States are available on the SCRAM Bulletin Board (http://www.epa.gov/scram001) and from a number of other sources. Because of the time required to develop dispersion factors, it was not feasible to include dispersion factors in IWAIR for all of these stations. Therefore, EPA developed an approach to select a subset of these stations for use in IWAIR. This approach considers the factors most important for the inhalation pathway risk modeling done by IWAIR.

The approach used involved two main steps:

1. Identify contiguous areas that are sufficiently similar with regard to the parameters that affect dispersion that they can be reasonably represented by one meteorological station. The parameters used were

   - Surface-level meteorological data (e.g., wind patterns and atmospheric stability)
   - Physiographic features (e.g., mountains, plains)
   - Bailey's ecoregions and subregions
   - Land cover (e.g., forest, urban areas).

2. For each contiguous area, select one meteorological station to represent that area. The station selection step considered the following parameters:

   - Industrial activity
   - Population density
   - Location within the area
   - Years of meteorological data available
   - Average wind speed.

These steps are described in the following sections.

D.1 Identify Contiguous Areas

A hierarchical procedure based on features affecting wind flow was used to divide the country into regions. The primary delineation of areas was based on geographic features affecting synoptic (broad area) winds, including mountain ranges and plains. These features are also known as physiography. Data were obtained from Fenneman and Johnson (1946), Wahrhaftig (1965), and State of Hawaii (1997). The secondary delineation was based on features affecting mesoscale (10 to 1,000 km) winds, including coastal regions and basic land cover classifications of forest, agriculture, and barren lands. These land cover features were obtained from U.S. Geological Survey (1999).

The methodology for identifying contiguous areas used wind data and atmospheric stability data derived from surface-level meteorological data as the primary consideration, modified by physiography, Bailey's ecoregions and subregions, and land cover. The approach focused on how well the wind speed and direction and atmospheric stability patterns measured at a surface-level meteorological station represented the surrounding area. The limit of appropriate representation varied by area of the country and was substantially determined by terrain and topography. For example, a station in the Midwest, where topography and vegetation are uniform, may adequately represent a very large area, while a mountainous station, where ridges and valleys affect the winds, may represent a much smaller area.

D.1.1 Primary Grouping on Wind-Rose and Atmospheric Stability Data

The surface-level meteorological data were downloaded from EPA's SCRAM Web site (www.epa.gov/scram001). SCRAM has these data for 1984 to 1991. A 5-year period is commonly used to obtain an averaged depiction of the winds for each station; 5 years covers most of the usual variation in meteorological conditions. EPA selected a single 5-year period (1986 to 1990) from the middle of the available period for the purpose of comparing wind roses. A single period provided consistency across stations. Not all stations had 5 years of data in this time period. Three years of data was considered a desirable minimum; therefore, stations that had less than 3 years of data during this time period were not considered for selection. A total of 223 stations in the contiguous 48 states were considered, plus 17 in Alaska, 3 in Hawaii, and 1 in Puerto Rico.

Two types of wind data were considered: wind directionality and wind speed. Wind directionality describes the tendency of winds to blow from many different directions (weakly directional) or primarily from one direction (strongly directional). Strongly directional winds will tend to disperse air pollutants in a consistent direction, resulting in higher air concentrations in that direction and higher overall maximum air concentrations. Weakly directional winds will tend to disperse pollutants in multiple directions, resulting in lower air concentrations in any one direction and lower overall maximum air concentration.

Wind speed also affects dispersion. A greater average wind speed tends to disperse pollutants more quickly, resulting in lower air concentrations than lower average wind speeds would produce. Wind speed was used in the station selection process, but not to identify contiguous areas of the country.

A wind rose is a graphical depiction of the frequency of wind speeds by wind direction (see Figure D-1). Wind roses were produced from the surface-level meteorological data for each station using WRPLOT (available from www.epa.gov/scram001/models/relat/wrplot.zip). Winds are plotted in 16 individual directions; thus, if every direction has the same frequency, the wind would blow from each direction 6.25 percent of the time. Based on the wind roses, each station was assigned to one of four bins based on the frequency of wind in the predominant direction (the direction from which the wind blows the greatest percentage of the time). These bins were as follows:

- W, weakly directional: blowing from the predominant direction less than 10 percent of the time

- A, mildly directional: blowing from the predominant direction 10 to 14 percent of the time

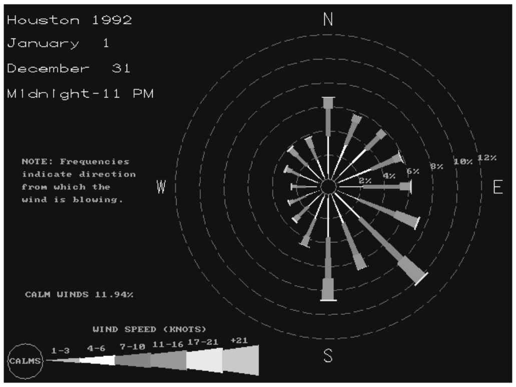
- B, moderately directional: blowing from the predominant direction 15 to 20 percent of the time

- C, strongly directional: blowing from the predominant direction more than 20 percent of the time.

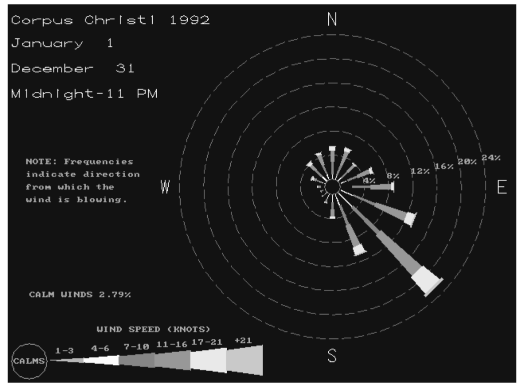
Atmospheric stability class frequency distributions were also used for some stations. Atmospheric stability is a measure of vertical movement of air and can be classified as stable, unstable, or neutral. For sources at ground level and slightly elevated (i.e., not tall stacks), such as are modeled in IWAIR, pollutants tend to stay close to the ground in a stable atmosphere, thereby increasing the air concentration of the pollutant. In an unstable atmosphere, the pollutants will tend to disperse more in the vertical direction, thereby decreasing the air concentration of the pollutant. Atmospheric stability varies throughout the day and year, as well as by location, because atmospheric stability is determined from variable factors such as wind speed, strength of solar radiation, and the vertical temperature profile above the ground. In addition, the presence of large bodies of water, hills, large urban areas, and types and height of vegetation all affect atmospheric stability. If all other factors are the same at two stations, the one with stable air a larger percentage of the time will have higher air concentrations than the station with stable air a smaller percentage of the time.

Stability class distributions were readily available for only 108 of the 223 stations considered for the United States. To apply the stability class data, the distributions were summarized as percent unstable, percent neutral, and percent stable.

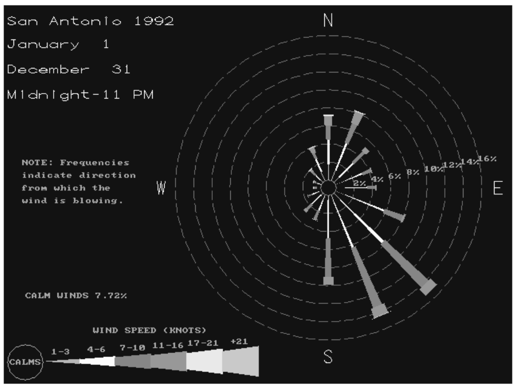
All stations with their assigned wind-rose bins and stability class distributions were marked on a map and then grouped geographically with others nearby with the same or an adjacent assigned bin and a similar stability class distribution. Figure D-1 illustrates the usefulness of this approach with respect to wind-rose data. It shows the 1992 wind roses for eight cities in Texas and Louisiana. A visual inspection of these graphics reveals that the wind patterns for these stations differ significantly.



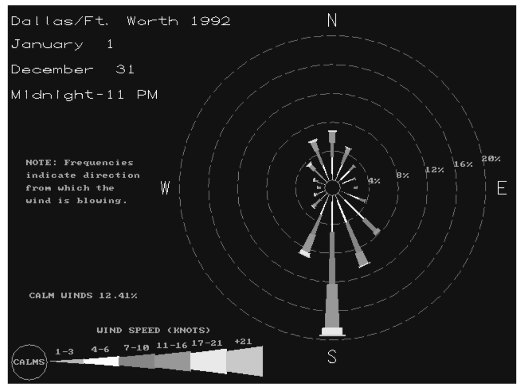
Houston, Texas, 1992.



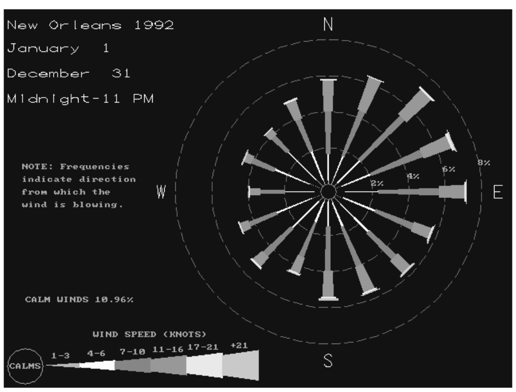
Corpus Christi, Texas, 1992.



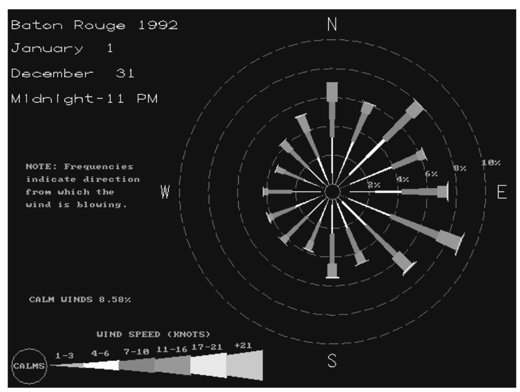
San Antonio, Texas, 1992.



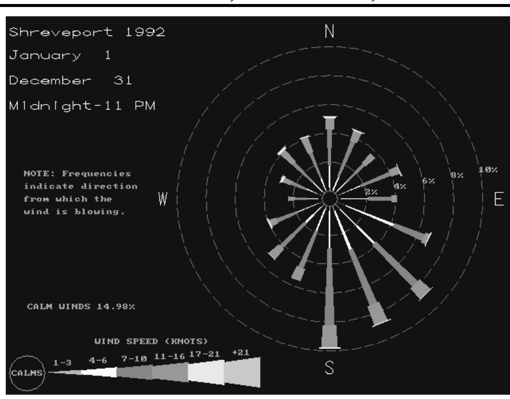
Dallas/Ft. Worth, Texas, 1992.



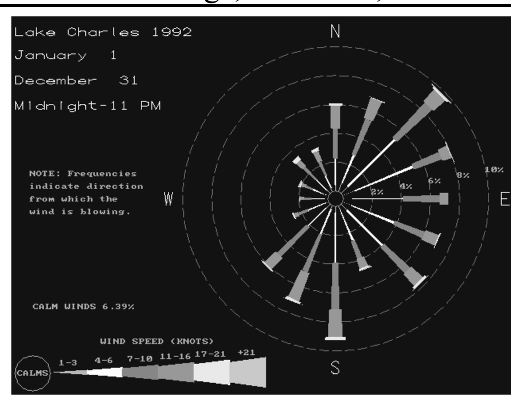
New Orleans, Louisiana, 1992.



Baton Rouge, Louisiana, 1992.



Shreveport, Louisiana, 1992.



Lake Charles, Louisiana, 1992.

Figure D-1. Wind-rose data for Texas and Louisiana.

D.1.2 Secondary Grouping Considerations

After spatially grouping the wind roses in similar bins, the next step was to delineate geographic areas around these groups of meteorological stations using maps of physiography, Bailey's ecoregions, and land cover. Physiography includes major topographic features, such as mountains or plains. Land cover classifications include urban, crop land, grassland, forest, large waterbody, wetland, barren, and snow or ice. Regional boundaries were chosen to coincide with physiographic, Bailey's ecoregion, and land cover boundaries to the extent possible.

D.2 Station Selection

The above approach used to delineate contiguous areas ensures that the stations grouped together are fairly similar in most cases. Therefore, the selection of an appropriate station to represent each area was based on other considerations, including

- **Previous EPA work on meteorological station selection.** Earlier efforts already identified stations that were representative of broad regions.
- **Number of years of surface-level meteorological data available.** More years of data provide a more realistic long-term estimate of air concentration.
- **Industrial activity**, based on TRI facility locations. More industrial activity suggests these locations are representative of more potential IWAIR users.
- **Population density**, based on land cover data. High population density in urban areas indicates more potential receptors; therefore, these are areas EPA would like to represent very well, so as to minimize potential error and uncertainty.
- **Central location within the area.** All other factors being equal, central locations are more likely to be representative of the entire contiguous geographic area because they have the smallest average distance from all points in the region.
- **Wind speed.** Lower wind speeds lead to less dispersion and higher air concentrations.

EPA considered two previous studies covering meteorological station selection. An assessment for EPA's Superfund program Soil Screening Levels (SSLs) (EQM and Pechan, 1993) selected a set of 29 meteorological stations as being representative of the nine general climate regions of the contiguous 48 states. In EPA's SSL study, it was determined that 29 meteorological stations would be a sufficient sample to represent the population of 200 meteorological stations and predict mean dispersion values with a high (95 percent) degree of confidence. The 29 meteorological stations were distributed among nine climate regions based on meteorological representativeness and variability across each region. These 29 stations have been used in a variety of EPA studies. The 2001 Surface Impoundment Study (SIS) (U.S. EPA, 2001) added 12 stations to the list of 29 for assessment of inhalation risks.

Industrial activity was based on a map of the locations of the WMUs in the 1985 Industrial D database (Schroeder et al., 1987) and facilities listing on-site land disposal-based emissions in the 1998 TRI (U.S. EPA, 2000). Population density was considered by identifying urban areas on the land cover map. Wind speed was summarized as average speed in the prevailing wind direction. This value is not readily extractable from the wind roses; therefore, it was obtained from the *International Station Meteorological Climate Summary* CD (NOAA, 1992) of meteorological data. For a few stations, this value was unrealistically low; in those cases, an average wind speed in the prevailing wind direction was estimated from the wind rose data.

EPA used a hierarchical procedure to select a representative station, as follows:

- If the area contained one of the 29 SSL stations, it was selected.
- If the area contained one of the stations added to the SSL list for the SIS, it was selected.
- Stations with less than 5 years of data in SCRAM were eliminated, unless no station had 5 years of data.
- Stations in locations with greater industrial activity (as indicated by TRI facilities reporting on-site land-based disposal) or greater population (based on urban areas from land cover maps) were preferred.
- Stations centrally located in the area were preferred if the above factors did not identify a clear choice.
- If all other factors were equal, stations with lower average wind speeds were selected to ensure that air concentration was not underestimated. Variations in wind speed within regions were minor.

D.3 New Meteorological Station Boundaries by Region

As a result of this work, the list of 60 stations shown in Table D-1, sorted by state and station name, was chosen for use in IWAIR. Appendix D-1 provides additional data on all of the meteorological stations considered. Selection of the stations is discussed in the following sections; for purposes of that discussion, the United States was divided into the following sections: West Coast, Desert Southwest, Western Mountains, Texas (excluding the Gulf Coast), Gulf Coast, Southeast, Middle Atlantic, Northeast, Great Lakes, Central States, Alaska, Hawaii, and Puerto Rico. The process of selecting stations and delineating the region assigned to each station is discussed by these sections.

Figure D-2 shows the selected stations and their assigned regions for the contiguous 48 states. Figures D-3, D-4, and D-5 show these boundaries on a larger scale for the western, southeastern, and northeastern United States overlaid on the location of facilities from the 1998 TRI data. The Bailey's ecoregions, physiographic features, and land cover were instrumental in

Table D-1. Surface-Level Meteorology Stations in IWAIR

Station Number	Station Name	State
26451	Anchorage/WSMO Airport	AK
25309	Juneau/International Airport	AK
13963	Little Rock/Adams Field	AR
23183	Phoenix/Sky Harbor International Airport	AZ
93193	Fresno/Air Terminal	CA
23174	Los Angeles/International Airport	CA
24257	Redding/AAF	CA
23234	San Francisco/International Airport	CA
23062	Denver/Stapleton International Airport	CO
14740	Hartford/Bradley International Airport	CT
12839	Miami/International Airport	FL
12842	Tampa/International Airport	FL
13874	Atlanta/Atlanta-Hartsfield International	GA
03813	Macon/Lewis B Wilson Airport	GA
22521	Honolulu/International Airport	HI
94910	Waterloo/Municipal Airport	IA
24131	Boise/Air Terminal	ID
94846	Chicago/O'Hare International Airport	IL
03937	Lake Charles/Municipal Airport	LA
12916	New Orleans/International Airport	LA
13957	Shreveport/Regional Airport	LA
14764	Portland/International Jetport	ME
94847	Detroit/Metropolitan Airport	MI
14840	Muskegon/County Airport	MI
14922	Minneapolis-St Paul/International Airport	MN
13994	St. Louis/Lambert International Airport	MO
13865	Meridian/Key Field	MS
24033	Billings/Logan International Airport	MT
03812	Asheville/Regional Airport	NC
13722	Raleigh/Raleigh-Durham Airport	NC

(continued)

Table D-1. (continued)

Station Number	Station Name	State
24011	Bismarck/Municipal Airport	ND
14935	Grand Island/Airport	NE
23050	Albuquerque/International Airport	NM
23169	Las Vegas/McCarran International Airport	NV
24128	Winnemucca/WSO Airport	NV
14820	Cleveland/Hopkins International Airport	OH
93815	Dayton/International Airport	OH
13968	Tulsa/International Airport	OK
94224	Astoria/Clatsop County Airport	OR
24232	Salem/McNary Field	OR
14751	Harrisburg/Capital City Airport	PA
13739	Philadelphia/International Airport	PA
14778	Williamsport-Lycoming/County	PA
11641	San Juan/Isla Verde International Airport	PR
13880	Charleston/International Airport	SC
13877	Bristol/Tri City Airport	TN
13897	Nashville/Metro Airport	TN
23047	Amarillo/International Airport	TX
13958	Austin/Municipal Airport	TX
12924	Corpus Christi/International Airport	TX
03927	Dallas/Fort Worth/Regional Airport	TX
12960	Houston/Intercontinental Airport	TX
23023	Midland/Regional Air Terminal	TX
24127	Salt Lake City/International Airport	UT
13737	Norfolk/International Airport	VA
14742	Burlington/International Airport	VT
24233	Seattle/Seattle-Tacoma International	WA
24157	Spokane/International Airport	WA
03860	Huntington/Tri-State Airport	WV
24089	Casper/Natrona Co International Airport	WY

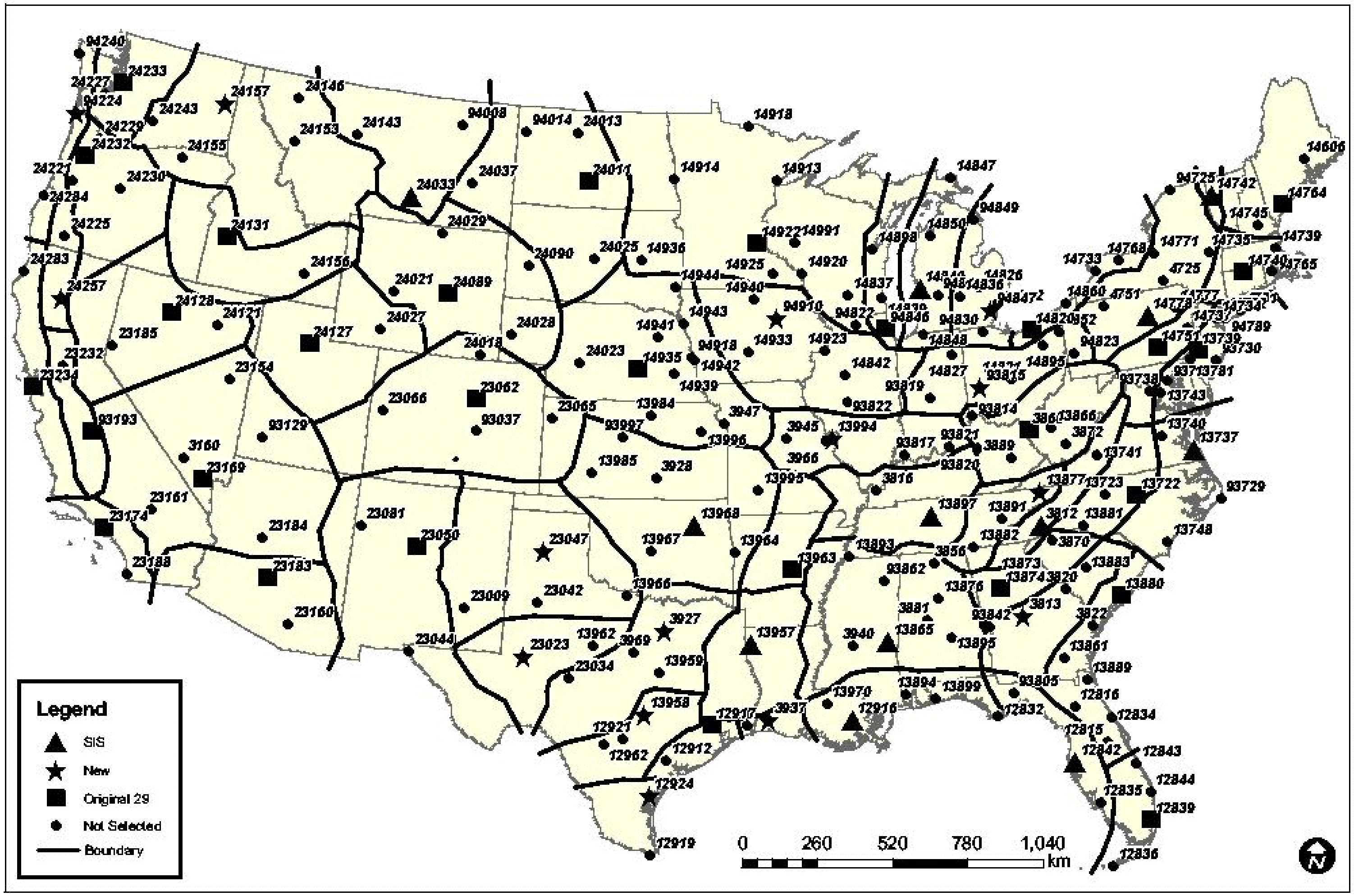


Figure D-2. Meteorological stations and region boundaries for the contiguous 48 states.

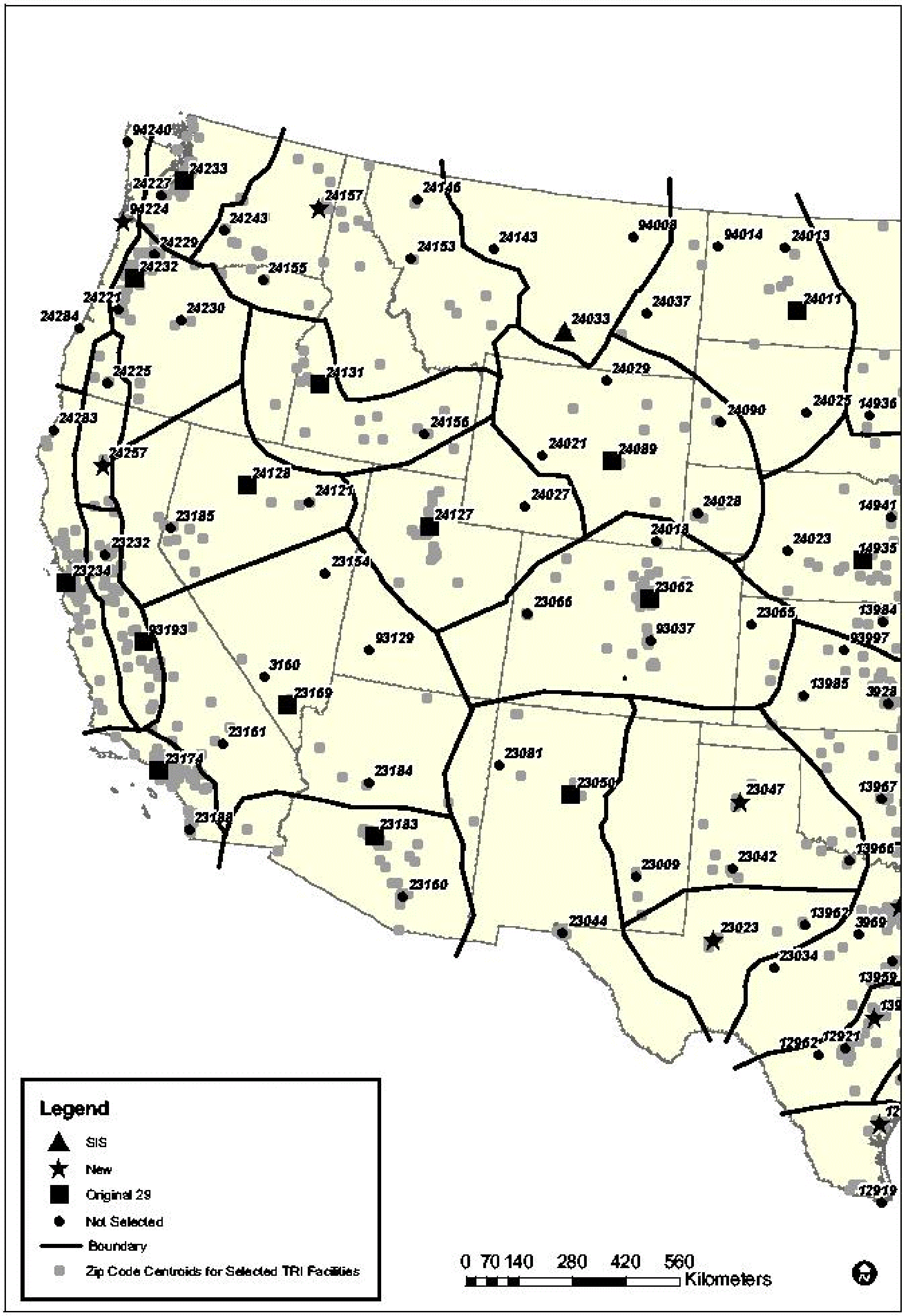


Figure D-3. Meteorological stations and region boundaries for the western United States with TRI facilities.

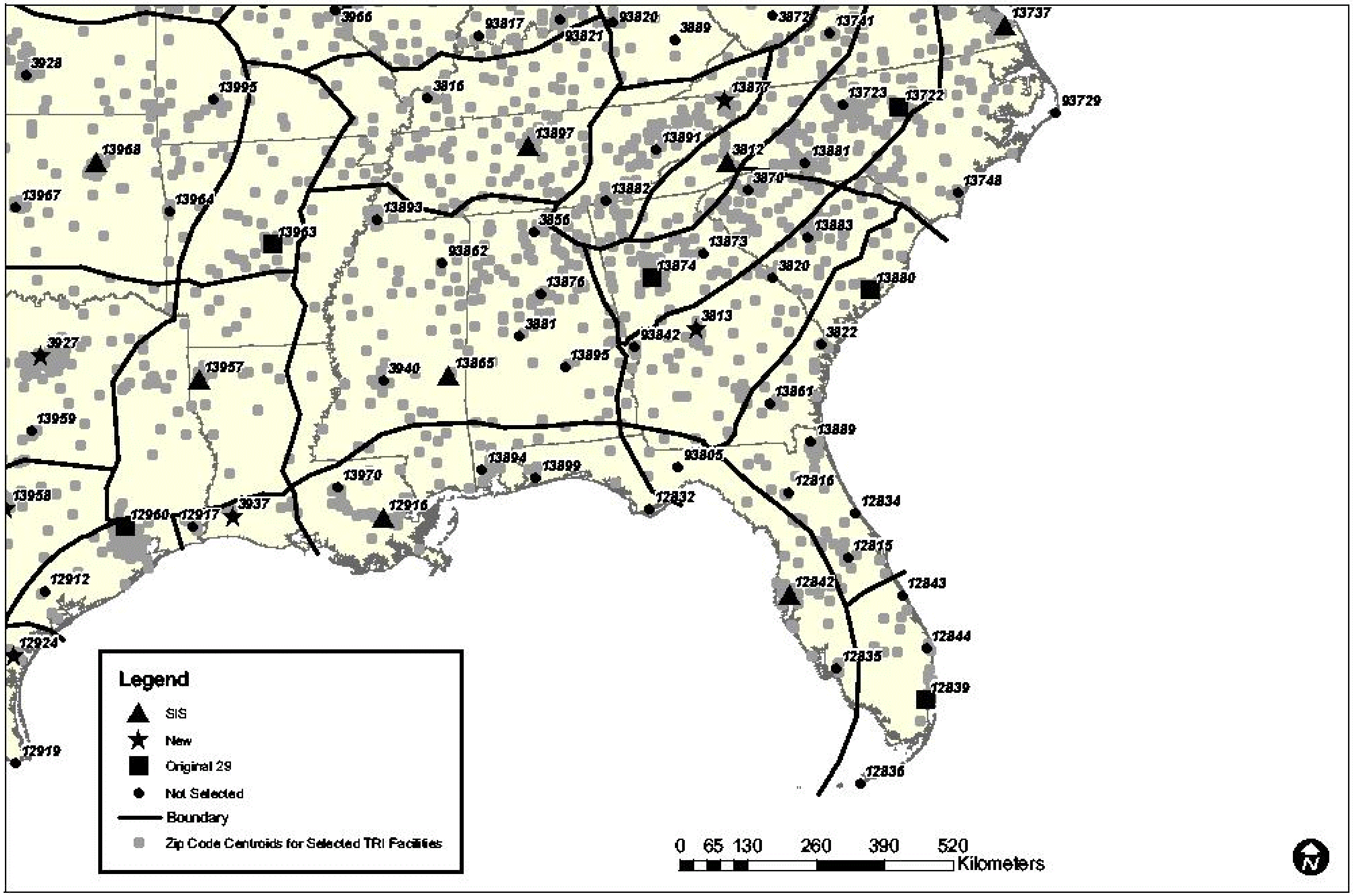


Figure D-4. Meteorological stations and region boundaries for the southeastern United States with TRI facilities.

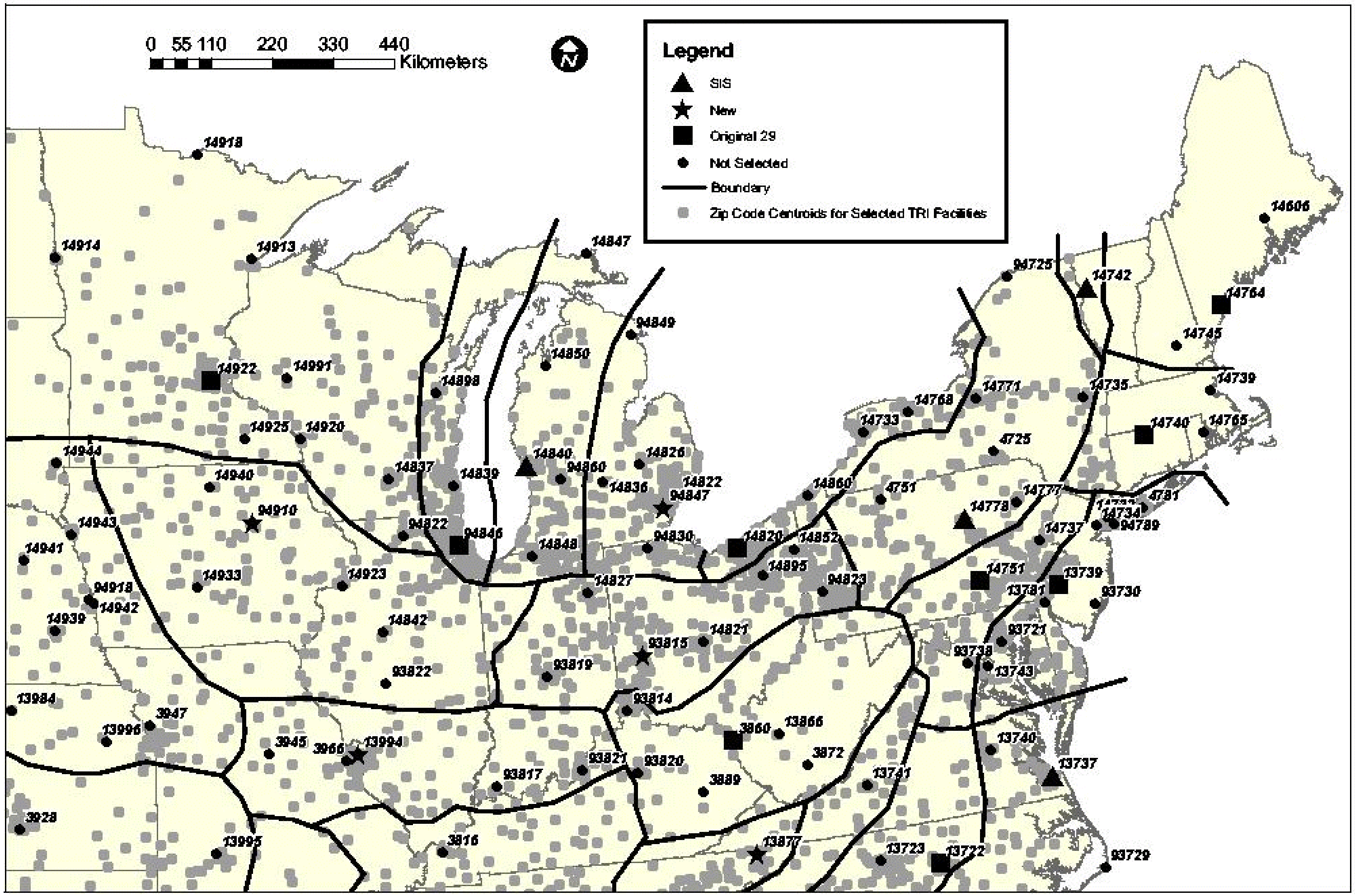


Figure D-5. Meteorological stations and region boundaries for the northeastern United States with TRI facilities.

assigning final boundaries for each selected station. Figures D-6, D-7, and D-8 also show the contiguous 48 states and the selected stations overlaid on Bailey's ecoregions, physiographic features, and land cover, respectively. Figures D-9 and D-10 show physiographic features for Alaska and Hawaii, respectively.

D.3.1 West Coast

The West Coast is defined by a narrow coastal plain and mountain chains running parallel to the coast of the Pacific Ocean. In many areas, the mountainous region is broken by a large central valley, such as in California. Due to the potential number of facilities in California that may use IWAIR, the California central valley was regionally delineated; the central valleys in Washington and Oregon were combined with some rural mountainous areas to their east.

The northwestern Pacific coast contains a narrow plain between the Pacific Ocean and the Coast Ranges. The **Astoria/Clatsop** County Airport station (94224) in Oregon represents the region from the Strait of Juan de Fuca south to the Oregon/California border. The wind rose shows generally weak directionality (bin W), and the average wind speed is 8 knots.

The California coast is divided just north of Point Conception above Los Angeles. The northern section is represented by the **San Francisco** International Airport (23234). The wind rose shows strong directionality (bin C), and the average wind speed is 12 knots.

The southern California coast contains the Los Angeles basin south to the California/Mexico border. This region is represented by the **Los Angeles** International Airport (23174). The wind rose shows strong directionality (bin C), and the average wind speed is 8 knots.

The California central valley region, which encompasses the Sacramento Valley to the north and the San Joaquin Valley to the south, is defined by the Coast Range and Diablo Range on the west and the Sierra Nevada mountains on the east. The valley extends south to the northern rim of the Los Angeles basin. This valley was divided into two sections between Sacramento and Redding because of the variation in wind regimes. The southern section is represented by **Fresno** Air Terminal (93193). The wind rose shows strong directionality (bin C). The northern division, whose northern border is represented by an ecoregion change to the Willamette Valley and Puget Trough Section, is represented by the **Redding** AAF (24257). The wind rose shows moderate directionality (bin B).

The inland portion of Washington is bounded by the Coast Ranges on the west, the edge of the Humid Temperate Domain to the east, the Washington/Canada border to the north, and the Columbia River to the south. This region is represented by the **Seattle**-Tacoma International Airport (24233). The wind rose shows moderate directionality (bin B), and the average wind speed is 10 knots.